On SHAKY Ground -- Supplement

A Guide to Assessing Impacts of Future Earthquakes Using Ground Shaking Hazard Maps for the San Francisco Bay Area

SEPTEMBER 1998

ASSOCIATION OF BAY AREA GOVERNMENTS

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For information on ABAG's Earthquake Program, shaking intensity maps by city, other earthquake impacts, techniques for home retrofit, and retrofit contractors, see our Internet site at: *quake.abag.ca.gov*

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BACKGROUND AND INTRODUCTION

Why a Supplement?

Since the most recent release of ABAG's report, ***The San Francisco Bay Area - On SHAKY Ground*** (Ref. 1), many people have used the maps of ground shaking. During these past years, however, questions have been raised about appropriate and inappropriate uses of the maps. This supplementary document is intended to encourage more use, and more appropriate use, of ABAG's ground shaking hazard information for the San Francisco Bay Area.

We're Talking About Ground Shaking

The discussion in this document, as in ***On SHAKY Ground***, focuses on the earthquake hazard of ground shaking, and its secondary impacts on buildings and ground failure. Ground shaking is the cause of the vast majority of earthquake-related damage, deaths and injuries.

Some Words of Caution

The following maps and tables attempt to show the answers to several common questions. However, as with any general assessment of what ***might*** happen in the future, the maps and tables are imperfect and incomplete. Because large earthquakes are not an everyday common occurrence, our understanding of their impacts is limited. We generally know what types of damage will occur and what types of ground will have problems, but we cannot predict the specific damage to specific buildings. This lack should not serve as an excuse to not act. There are many things that each of us can do as individuals, and working with our neighbors, offices and agencies, to reduce the risk of damage and other earthquake effects. Thus, it is very important that you read the materials explaining:

- ♦ What question each map and table is trying to answer;
- ♦ When you might want to use the map or table, and when you should ***not*** use it;
- ♦ How each type of map or chart was prepared; and
- ♦ What assumptions we needed to make to prepare the maps and charts, including what information is unknown.

***This report supplements the ABAG report,* The San Francisco Bay Area - On *SHAKY* Ground.**

This report is intended to supplement the ABAG report, ***The San Francisco Bay Area – On SHAKY Ground*** (Ref. 1). Therefore, information on the way in which ABAG's ground shaking maps are created for individual scenario earthquakes is included in that earlier report and is not repeated in this supplement.

PART I

WHAT DOES GROUND SHAKING INTENSITY REALLY MEAN?

"Official" Modified Mercalli Intensity Descriptions Can Be Confusing

On SHAKY Ground (Ref. 1) provides maps showing modeled shaking intensity for expected future earthquakes using the modified Mercalli intensity (MMI) scale. The full description of each intensity level is provided in that report and in the Table 1 on the following page. However, these "official" descriptions of each MMI level in Table 1 were written approximately 40 years ago (Ref. 2) and are often difficult to interpret, vague and archaic.

Current Research Provides Examples of MMI Impacts on the Following Pages

We can now provide more "quantitative" descriptions of the impacts of shaking on buildings, probabilities of ground failure (including liquefaction and landsliding), and conversions among intensity scales and to other measures of shaking strength than were provided by the "official" descriptions in Table 1. These data are based on research by ABAG and others in the past few years, and are provided on the following pages.

TABLE 1: Modified Mercalli Intensity Scale Summary Descriptions and "Official" Full Description

MMI Value	Description of Shaking Severity	Summary Damage Description Used on 1995 Maps	**"Official" Full Description** (from Ref. 2, written in 1958)
I.			Not felt. Marginal and long period effects of large earthquakes.
II.			Felt by persons at rest, on upper floors, or favorably placed.
III.			Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV.			Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV wooden walls and frame creak.
V.	Light	Pictures Move	Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.
VI.	Moderate	Objects Fall	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle).
VII.	Strong	Nonstructural Damage	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
VIII.	Very Strong	Moderate Damage	Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX.	Violent	Heavy Damage	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluvial areas sand and mud ejected, earthquake fountains, sand craters.
X.	Very Violent	Extreme Damage	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI.			Rails bent greatly. Underground pipelines completely out of service.
XII.			Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

Shaking Intensity and Building Damage

The Question

☑ **How does ground shaking intensity relate to damage to various types of building construction?**

What We Know

The likelihood of building damage is radically different for different types of buildings. After the Northridge earthquake, the Superior Apartments (shown below) were heavily damaged. However, a group of single family homes behind the apartments experienced little damage. These apartments were constructed to comply with modern building codes.

The damage to buildings can be depicted using two separate measures of damage:

1) the percentage of buildings of a particular construction type (defined by use, construction materials, height and age) "red-tagged" by the local government building inspector as "unsafe for human occupancy," that is, ***uninhabitable***, or
2) the average ***dollar loss*** (expressed as a percentage of the replacement value) for each construction type.

Based on information compiled by ABAG for residential construction (Ref. 3) and by EQE and OES for commercial construction (Ref. 4), it is relatively easy to generate a table of percent of housing units and commercial buildings typically "red tagged" for several construction types, as shown in Table 2.

What We Don't Know

Although a table of average dollar loss by construction type might, arguably, be more useful than the habitability information provided here, it is our judgement that information is insufficient to create such a table at this time. Data on the value of buildings "at risk" in past earthquakes and reliable damage data are scarce.

In addition, there is no reliable data on the habitability of tilt-up concrete buildings (separate from other types of concrete buildings), or on wood-frame commercial buildings (separate from residential buildings). Information on these two types of buildings is therefore not included in Table 2.

Example of Damage to
Post-1940s Multi-Family Residential
(Superior Apartments, Northridge)
Source: Jeanne Perkins, ABAG

Example of Damage to
Mobile Home
Source: Karl Steinbrugge

Example of Damage to
Unreinforced Masonry Café and Hotel
Source: Henry Degenkolb

Example of Damage to Concrete Building
Source: Northridge Earthquake Collection, Earthquake Engineering Research Center, University of California, Berkeley

TABLE 2: Percent of Dwelling Units (for Residential) and Buildings (for Commercial) Red Tagged by Construction Type and MMI Intensity

RESIDENTIAL TYPE[1]	INTENSITY					
	V	VI	VII	VIII	IX	X+
Mobile Homes	almost 0	0	0.87	40	90	100
Unreinforced Masonry	almost 0	0.05	2.9	45	70	80
Non-Wood , 4-7 Stories, <1940	almost 0	0.30	8.0	45	70	80
Wood-Frame, 4-7 Stories, <1940, Multi-Family	almost 0	1.4	2.5	45	70	80
Wood-Frame, 1-3 Stories, <1940, Multi-Family	almost 0	0.05	0.53	11	44	64
Wood-Frame, 1-3 Stories, >1939, Multi-Family[2]	almost 0	0.01	0.04	6.5	15	25
Wood-Frame, 1-3 Stories, <1940, Single Family[3]	almost 0	0.04	0.12	1.8	8.4	12
Wood-Frame, 1-3 Stories, >1939, Single Family	almost 0	0	0.02	0.18	0.69	1.8
COMMERCIAL OR INDUSTRIAL						
Unreinforced Masonry[4]	almost 0	1.0	8.0	45	70	80
Miscellaneous Concrete[5]	almost 0	0	1.0	20	33	40

Note 1. The relationships between intensity and construction type for residential buildings are taken from Ref. 3 (pg. 68).
*Note 2. **These percentages include a mixture of buildings with and without full or partial parking underneath the structure. Data for buildings with and without parking are not directly available. However, the values for multi-family buildings without parking are probably closer to those for >1939 wood-frame single family homes, and those for buildings with parking could easily be double the percentages listed here.***
Note 3. Homes built prior to 1940 were not bolted to their foundations. However, these percentages include an unknown mixture of homes that have, and have not, been retrofitted by adding these bolts and installing plywood sheathing on the inside of the crawl space.
Note 4. Note that the percentages of commercial unreinforced masonry buildings red tagged are higher than those for the residential unreinforced masonry because these buildings typically have fewer room partitions.
Note 5. Taken from Ref. 4 (Table 4-3), except for MMI VII (which was revised downward from 8% to 1% based on lack of damage in the Loma Prieta earthquake). These percentages apply to "general" concrete buildings.

Shaking Intensity and Landsliding ...

The Question

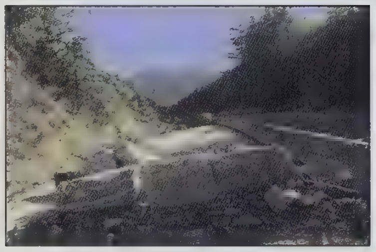
☑ Can ground shaking intensity be correlated to earthquake-triggered landsliding?

What Is the Hazard?

Landslides are often triggered by the shaking of earthquakes. These ground failures are of two principal types (Ref. 5):

- ***disrupted slides, falls and flows*** – landslides with highly jumbled materials that start on steep slopes and move at relatively high speeds, such as soil or rock slides, rock falls and avalanches, and debris flows; and
- ***coherent slides*** – blocks of unjumbled materials that move on a discrete slide surface, such as slumps, block slides and earth flows.

What We Know



Source:
Gerald Wieczorek, USGS
Loma Prieta, Calif. Earthquake of Oct. 17, 1989

The California Division of Mines and Geology (CDMG) has a program to map earthquake-induced landslide hazard areas throughout California. Currently only portions of Los Angeles, Orange and Ventura counties, have been mapped as part of this program. No Bay Area mapping has been completed.

Mapping of Oakland is scheduled to begin in late 1998 and will take about a year to complete. Additional mapping in the Bay Area is subject to the availability of state and federal funding. The program is mandated by the Seismic Hazards Mapping Act (Public Resources Code, Ch. 7.8)

Much effort was made to document the location, shape, and severity of the landslides triggered by the October 1989 Loma Prieta earthquake and the January 1994 Northridge earthquake. Approximately 1,500 earthquake-triggered landslides were mapped, and up to 4,000 slides may have moved, in the Loma Prieta earthquake (Ref. 6). Over 11,000 landslides occurred in the Northridge earthquake (Ref. 7). Significantly, both earthquakes occurred when the ground was exceptionally dry. Extensive research on the distribution and causes of these slides shows that failure rates can be correlated with (1) shaking severity; (2) slope steepness; (3) strength and engineering properties of geologic materials; (4) water saturation (which varies with precipitation and by season); (5) existing landslide areas; and (6) vegetative cover.

Researchers have correlated areas of known earthquake-induced landslides to Arias intensity, a measure of ***shaking severity*** defined on page 11. Areas subjected to Arias intensities of greater than about 0.54 m/sec commonly have earthquake-triggered landslides. Table 7 on page 11 shows this intensity is roughly equivalent to a modified Mercalli intensity of VII or greater. Small numbers of landslides can occur at MMI VI.

Slope length and slope aspect (that is, orientation facing north, south or somewhere in between) contribute to earthquake-induced landslide susceptibility. However, ***slope steepness*** (as expressed in percent slope) is the most critical slope factor.

The mapped geologic units in the Bay Area can be grouped according to an approximate ***material shear strength*** classification of A, B, or C, with A being those units least susceptible to sliding and C being those units most susceptible to sliding. A table correlating these geologic material units with their shear strength classifications is included in ***Riding Out Future Quakes*** (Ref. 8, Appendix C).

What We Know (continued)

The final factor included in this analysis is degree of ***water saturation***. This variable depends in large part on length of time since the last major storm and rainfall to date. Because these data cannot be known ahead of time, two tables correlating landslide susceptibility with saturation have been generated - one for dry (summer) conditions and a second for wet (winter) conditions. The intensities required for landslides tend to be lowered by approximately one intensity unit under wet conditions.

What We Don't Know

Two important factors contributing to earthquake-induced landslide susceptibility have not been incorporated into these tables.

First, ***existing landslides*** are not included because any compilation of data on their location is presently sporadic; no regional depository exists for the wealth of data collected for individual development projects.

Second, ***vegetative cover*** is not incorporated into the following tables because very little research has been conducted quantifying its effect.

TABLE 3: Earthquake-Induced Landslide Susceptibility – Dry (Summer) Conditions – Based on Modified Mercalli Intensity (MMI), Percent Slope, and Material Type (A, B or C)[1]

[Values in this table are the percentage of the land units being analyzed expected to have at least one landslide. The land units analyzed are one hectare squares, or units 100 meters on each side.]

Percent Slope	0 - 5 % Slope			6 - 15 % Slope			16 - 30 % Slope			30+ % Slope		
Material Type	A	B	C	A	B	C	A	B	C	A	B	C
MMI IX and X	0	1	2	1	2	12	5	8	18	8	18	30
MMI VIII	0	0	0	0	0	5	0	5	12	5	8	18
MMI VII	0	0	0	0	0	3	0	3	4	3	5	12
MMI VI	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 4: Earthquake-Induced Landslide Susceptibility – Wet (Winter) Conditions – Based on Modified Mercalli Intensity (MMI), Percent Slope, and Material Type (A, B or C)[1]

[Values in this table are the percentage of the land units being analyzed expected to have at least one landslide. The land units analyzed are one hectare squares, or units 100 meters on each side.]

Percent Slope	0 - 5 % Slope			6 - 15 % Slope			16 - 30 % Slope			30+ % Slope		
Material Type	A	B	C	A	B	C	A	B	C	A	B	C
MMI IX and X	1	2	12	5	8	18	8	18	30	12	24	50
MMI VIII	0	1	2	1	2	12	5	8	18	8	18	30
MMI VII	0	0	0	0	0	5	0	5	12	5	8	18
MMI VI	0	0	0	0	0	3	0	3	4	3	5	12

*Note 1. A table correlating these geologic material units with their shear strength classifications is included in **Riding Out Future Quakes** (Ref. 8, Appendix C).*

Shaking Intensity and Liquefaction ...

The Question

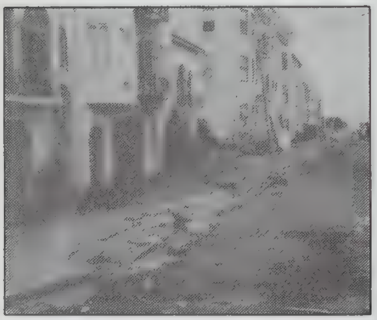
☑ Can shaking intensity be correlated to areas of liquefaction?

What Is the Hazard?

When the ground ***liquefies***, sandy materials which are saturated with water can behave like a liquid, instead of like solid ground. In essence, the sand grains momentarily behave like a liquid.

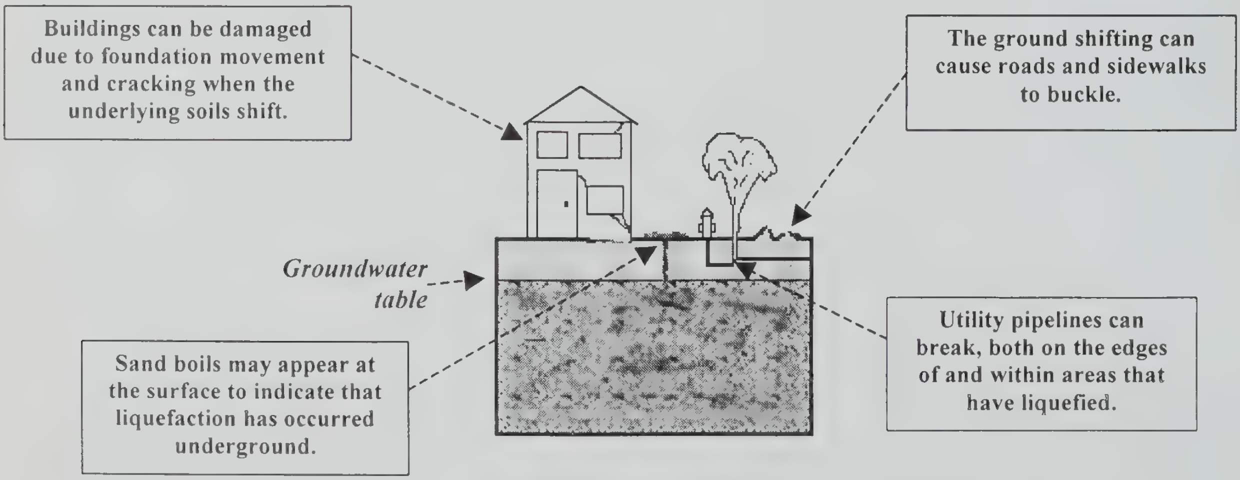
Liquefaction is defined as "the transformation of a granular material from a solid state into a liquefied state as a consequence of increased pore-water pressure" (Ref. 9, p. 1). Engineers call this "loss of shear strength." The ground needs to be shaken strongly for liquefaction to occur, and this shaking can occur as a result of an earthquake.

Liquefaction can cause ground displacement and ground failure. In addition, it can cause lateral spreads and flows (essentially landslides on flat ground next to rivers, harbors, and drainage channels).



Source:
Michael J. Bennett, USGS
Liquefaction, Marina District
Loma Prieta, Calif. Earthquake
of Oct. 17, 1989

POTENTIAL RESULTS OF LIQUEFACTION



What We Know

The liquefaction hazard from a given earthquake scenario is based on:

- geologic material;
- groundwater table (which indicates likelihood that those materials are saturated); and
- shaking severity.

Information on geologic material and groundwater are used to estimate the liquefaction susceptibility levels listed in Table 5, below. Our preliminary research indicates modified Mercalli intensity VIII or greater in areas with very high or high liquefaction susceptibility are typically required for liquefaction to be likely. However, MMI VII can be sufficient if materials are very highly susceptible to failure. Measurement and model errors make liquefaction in areas shaken even less severely a statistical possibility.

TABLE 5: Potential Likelihood for Liquefaction Based on a Combination of Shaking Intensity and Liquefaction Susceptibility

Modified Mercalli Intensity	Liquefaction Susceptibility	Likelihood of Liquefaction
IX and X	Very High	High
	High	High
	Moderate	Moderate
VIII	Very High	High
	High	High
	Moderate	Moderate
VII	Very High	High
	High	Moderate
	Moderate	Low
VI	Very High	Moderate
	High	Low
	Moderate	Low

Where We're Going

ABAG and William Lettis & Associates (WLA) are currently producing revised liquefaction susceptibility and liquefaction opportunity maps for the San Francisco Bay Area with funding from the U.S. Geological Survey. As part of that effort, additional data on the shaking required for liquefaction to take place are being collected. The final results of that research have not been incorporated into this assessment, which is therefore qualitative, rather than quantitative. Other researchers have conducted studies of the relationship between liquefaction and Arias intensity (see page 11 and Refs. 10 and 11). We plan to incorporate that research into the ABAG/WLA effort.

The California Division of Mines and Geology (CDMG) has a program to map liquefaction hazard areas throughout California. Currently, this type of Seismic Hazard Zone Map is only available for the northern half of San Francisco and several areas in Los Angeles, Ventura and Orange counties in southern California. CDMG will begin mapping of Oakland in the fall of 1998. The maps should take about a year to completeAdditional mapping is subject to the availability of state and federal funding. The program is mandated by the Seismic Hazards Mapping Act (Public Resources Code, Ch. 7.8)

Correlation of Shaking Intensity with Other Measures of Shaking Severity…

The Question

☑ **The modified Mercalli intensity scale seems so subjective. Can ABAG's intensity maps be converted to other, more quantitative, measures of shaking severity? What peak velocities or undamped velocity response spectra are roughly comparable to the shaking intensities shown on ABAG's maps?**

What We Know

The ABAG ground shaking intensity maps were produced using a model that predicts the decrease (attenuation) of shaking away from the fault source developed by J. Boatwright (Ref. 1). The model predicts the undamped velocity response spectra, in units of cm/sec (typical of a velocity measurement), not cm/sec^2 (units of acceleration). ***This model therefore predicts a parameter more closely related to velocity than acceleration, and does not model intensity directly.***

To predict intensity, we correlated the resulting model maps using both modified Mercalli intensity information and rarer San Francisco intensity information (from, largely, the 1906 San Francisco earthquake) in order to calibrate the model. We use units of intensity in the map legend because they are much easier for most people to understand. Typical intensity maps made by others use damage information and what people felt to map intensities of earthquakes which have already occurred. We have attempted to model these general effects in future earthquakes based on shaking severity information.

If, however, you want or need a ***quantitative*** measure of shaking strength, you can correlate the map legend to these other measurements using Table 7 on the following page. This table was generated using more information than was available for ***On Shaky Ground*** in 1995 (Ref. 1, pg. A46). It is consistent with ***Riding Out Future Quakes*** published in 1997 (Ref. 8, pg. 29).

What We Don't Know

Overall, however, there is a shortage of actual data from seismographs near the source faults of major earthquakes to test this theoretical model. The values need to be checked, and may need to be modified, following future major earthquakes.

The maps are intended to depict the relative severity of shaking in one area relative to other areas in the earthquakes modeled. They do not, nor can any general map created prior to an earthquake, be a substitute for evaluation of the level of shaking at a specific site made by qualified seismologists or geotechnical engineers, or assessment of the performance of a specific structure at that site by a licensed structural engineer.

Where to Go for Maps Showing Probability of Exceedance Information

Because the shaking severity maps for individual earthquakes are based on a shaking measurement called the undamped velocity response spectra, the maps could be combined to create a map based on the probability of exceeding this level. This scheme was used to create the probabilistic shaking hazard maps developed by the U.S. Geological Survey and the California Division of Mines and Geology (see Refs. 12 and 13) for peak horizontal ground acceleration, not undamped velocity response spectra used for ABAG's maps. The correlation between undamped velocity response spectra and peak acceleration is too weak to warrant inclusion in the table below.

TABLE 7: Approximate Relationships Among Intensity Scales, Particle Velocity and Undamped Velocity Response Spectra

NOTE – These correlations apply to the ABAG maps because of the way they were generated. ***They do not work with other MMI maps.*** Therefore, this table should not be used to convert MMI or San Francisco Intensity maps generated by others to Arias intensity, undamped velocity response spectra, or peak velocity.

Undamped Velocity Response Spectra[1] (cm/sec)	Peak Velocity (cm/sec)	Arias Intensity[2] (m/sec)	San Francisco Intensity	Modified Mercalli Intensity (as shown on ABAG maps)		
				Summary of Damage Used in 1995	Shaking Severity[3]	Roman Numeral
(more than shaking)						XII
(more than shaking)			A - Very Violent			XI
450	286	48.7		Extreme	Very Violent	X
300	191	21.6	B - Violent			
204	130	10.0		Heavy	Violent	IX
141	90	4.8	C - Very Strong			
96	61	2.2		Moderate	Very Strong	VIII
66	42	1.1	D - Strong			
45	30	0.5		Nonstructural	Strong	VII
30	19	0.2	E - Weak			
21	13	0.1		Objects Fall	Moderate	VI
15	10	0.05	<E - Very Weak			
9	6	0.02		Pictures Move	Light	V

Note 1. ***Undamped velocity response spectra is equivalent, but not identical, to average acceleration spectral level.*** The relationship between these quantities and the intensity values has been modified due to additional data gathered after the Loma Prieta and Northridge earthquakes (oral communication, J. Boatwright, U.S. Geological Survey). ***All of the quantitative measurements of shaking strength used in this table have units of velocity, not acceleration.***

Note 2. Arias intensity is an estimate of the energy delivered to structures on the earth's surface. The actual formula is provided in Ref. 10:

$$I_{\alpha} = \frac{\pi}{2g}\int_{0}^{\infty}[a(t)]^2\, dt$$

where I_{α} is Arias intensity, g is the acceleration of gravity, and the remaining term is the integral of the square of acceleration over time.

Note 3. As can be seen from this table, the terms for shaking intensity now being used on the ABAG maps are similar, but not identical, to those used to describe San Francisco intensity (an intensity scale used following the 1906 San Francisco earthquake). These qualitative terms do not refer to the same quantitative shaking levels, however.

PART II

HOW DO WE PLAN TO IMPROVE ABAG'S GROUND SHAKING INTENSITY MAPS?

Our Questions

Since 1995, ABAG and the U.S. Geological Survey have made significant improvements in a number of different areas which could be used to generate revised ground shaking hazard maps for the Bay Area. However, the research in a number of these areas is not yet at a point where it is worthwhile to revise the maps. The following pages describe some questions now being examined and provide a look at the current status of this research.

- ♦ How can we better predict the role of geologic materials in shaking intensity?
- ♦ Which Bay Area faults are capable of producing major earthquakes, and what is the likelihood that they will generate an earthquake in the next 30 years?
- ♦ How certain are we that we are selecting the "correct" fault segments when we subdivide major Bay Area faults into segments for use as sources of earthquakes in our models?
- ♦ What is the role of thrust faults in determining the Bay Area earthquake hazard?

ABAG and USGS hope to revise the ***On Shaky Ground*** maps for release in the Fall of 1999.

Improved Information on Geologic Materials…

The Question

☑ **Can more recent mapping of the geologic materials in the Bay Area's valleys be used to improve the quality of shaking hazard maps?**

Why We Want to Know

Most of the people in the Bay Area live and work in the valleys. Materials in these valleys tend to amplify the strong ground shaking more than materials on hillsides. Revised and more accurate mapping should lead to better maps modeling past earthquake damage, and therefore the severity of shaking in future earthquakes.

What We Know

William Lettis & Associates is working with the U.S. Geological Survey to improve the quality of mapping of the materials in these areas. That mapping should be completed by the Spring of 1999.

What We Don't Know

Once the revised mapping is available, ABAG researchers and others can use it to evaluate to what extent new information on geologic materials is a better predictor of past, and potentially future, shaking severity and damage patterns. If it is, then these maps will be incorporated into revised shaking intensity maps.

FIGURE – Relationship Between Categories of Young Geologic Materials in Flat Areas Used on 1995 Maps and Those Being Developed for Use in 1999 Revisions

Young Geologic Materials in Flat Areas Used in 1995 Source: Ref. 14	**Young Geologic Materials in Flat Areas for Use in 1999** Source: Ref. 15
Qu – Undivided Quaternary alluvium **af** – Artificial fill **Qhsc** – Holocene stream channel deposits **Qhbm** – Holocene Bay mud **Qhs** – Holocene beach and windblown sand **Qhaf** – Holocene fine-grained alluvium; fan and plain (basin) deposits **Qhafs** – Holocene fine-grained alluvium; fan and plain (basin) deposits – salt-affected **Qhac** – Holocene coarse-grained alluvium; fan and basin deposits **Qham** – Holocene medium-grained alluvium; fan and plain deposits **Qpa** – Pleistocene alluvium, undivided **Qps** – Pleistocene sand, including Merritt sand **Qpea** – Early Pleistocene alluvium **Qpmt** – Pleistocene marine terrace deposits	**Qha** – Undivided Quaternary alluvium **af** – Artificial fill **Qhc** – Modern stream channel deposits **Qhbm** – Holocene Bay mud deposits; includes channels **Qhs** – Holocene dune and beach sand **Qhb** – Holocene basin deposits **Qht** – Holocene terrace deposits **Qhf** – Holocene alluvial fan deposits **Qhl** – Holocene alluvial fan levee deposits **Qa** – Late Pleistocene to Holocene alluvium, undifferentiated **Qf** – Late Pleistocene to Holocene alluvial fan deposits **Qpa** – Pleistocene alluvium, undifferentiated **Qpf** – Late Pleistocene alluvial fan deposits **Qps** – Late Pleistocene dune and beach sand, including Merritt sand **Qmt** – Pleistocene marine terrace deposits **Qoa** – Early or middle Pleistocene alluvial deposits

Relative Activity of Bay Area Faults…

The Questions

☑ **Which Bay Area faults are capable of producing major earthquakes?**

☑ **What is the likelihood that they will generate an earthquake in the next 30 years?**

Why We Want to Know

One consideration when combining maps of shaking intensity from earthquakes on several different faults is which faults (and fault segments) should be considered. Some faults may have earthquakes, but those earthquakes are typically so small that they do not damage property.

Another consideration when producing composite maps is the relative activity of the various faults. Some researchers have generated a map that simply takes the "worst case" or maximum intensity value in each area to create a maximum intensity map. Although this type of map is useful for some applications, one problem with this type of map is that it gives undue importance to faults that are relatively less likely than others to generate a large earthquake, yet are likely enough to generate such a quake that they must logically be included. A repeat of the 1906 San Francisco earthquake on the entire San Andreas fault (with a 30-year probability of only 2%) or of the 1989 Loma Prieta earthquake (with an even lower 30-year probability) are examples of such earthquakes. On the other hand, the hazard associated with earthquakes on faults which are "overdue" is underestimated. An earthquake on the Northern Hayward fault (with a 30-year probability of 28%) is an example of this second problem.

How We Made the List of Major Bay Area Faults

Various researchers have produced lists of faults capable of generating major earthquakes affecting the San Francisco Bay Area. The most recent list, and the one most widely accepted at the present time, was prepared by the Working Group on Northern California Earthquake Potential (1996) (Ref. 16). This report provides information on 33 faults or fault segments which might impact the Bay Area.

Several of these segments are subdivisions of faults considered in the ***On SHAKY Ground*** report (Ref. 1). Several other segments are on thrust faults that are poorly understood. Finally, several are on the southern portion of the Calaveras fault, which is believed to be only capable of producing earthquakes that are relatively small (magnitude 6 or so), or approximately the size of the 1984 Morgan Hill (magnitude 6.3) or 1979 Coyote Lake (magnitude 6.0) earthquakes.

This Working Group did not compile information on several other faults in the Bay Area that are felt to be unlikely to generate a large (greater than magnitude 6) earthquake in the next 30 years or so. These faults are responsible for background seismicity and are often poorly

understood. An earthquake can occur on one or more of these other faults. However, they are much less likely to generate a significant earthquake than the major faults included in Table 8 and mapped on the following page.

What We Know About Earthquake Likelihood

The two principal sources of information about the likelihood of future earthquakes in the Bay Area used for this report are the same as the sources of lists of major active faults used – the reports of the Working Group on Northern California Earthquake Potential (1996) (Ref. 16) and the Working Group on California Earthquake Probabilities (1990) (Ref. 17). These reports form the basis for Table 8. In addition, the USGS/CDMG probabilities team (Ref. 13) developed a similar, but not identical, list of Bay Area faults and their probabilities.

What We Don't Know and What We're Working On

Earthquake probabilities on some fault segments in Table 8 on page 17 incorporate data on past earthquakes from Ref. 17 (see the final column of Table 8). However, these data are only published for a limited number of fault segments, in large part because of the limited information on most other faults. Therefore, in Table 8, we also provide information based on the random recurrence of earthquakes from Ref. 16 (see the next to last column of Table 8). The decision to combine these two sources of probability information in one table is different than the Working Group on Northern California Earthquake Potential (Ref. 16), or the USGS/CDMG probabilistic mapping (Ref. 12 and 13).

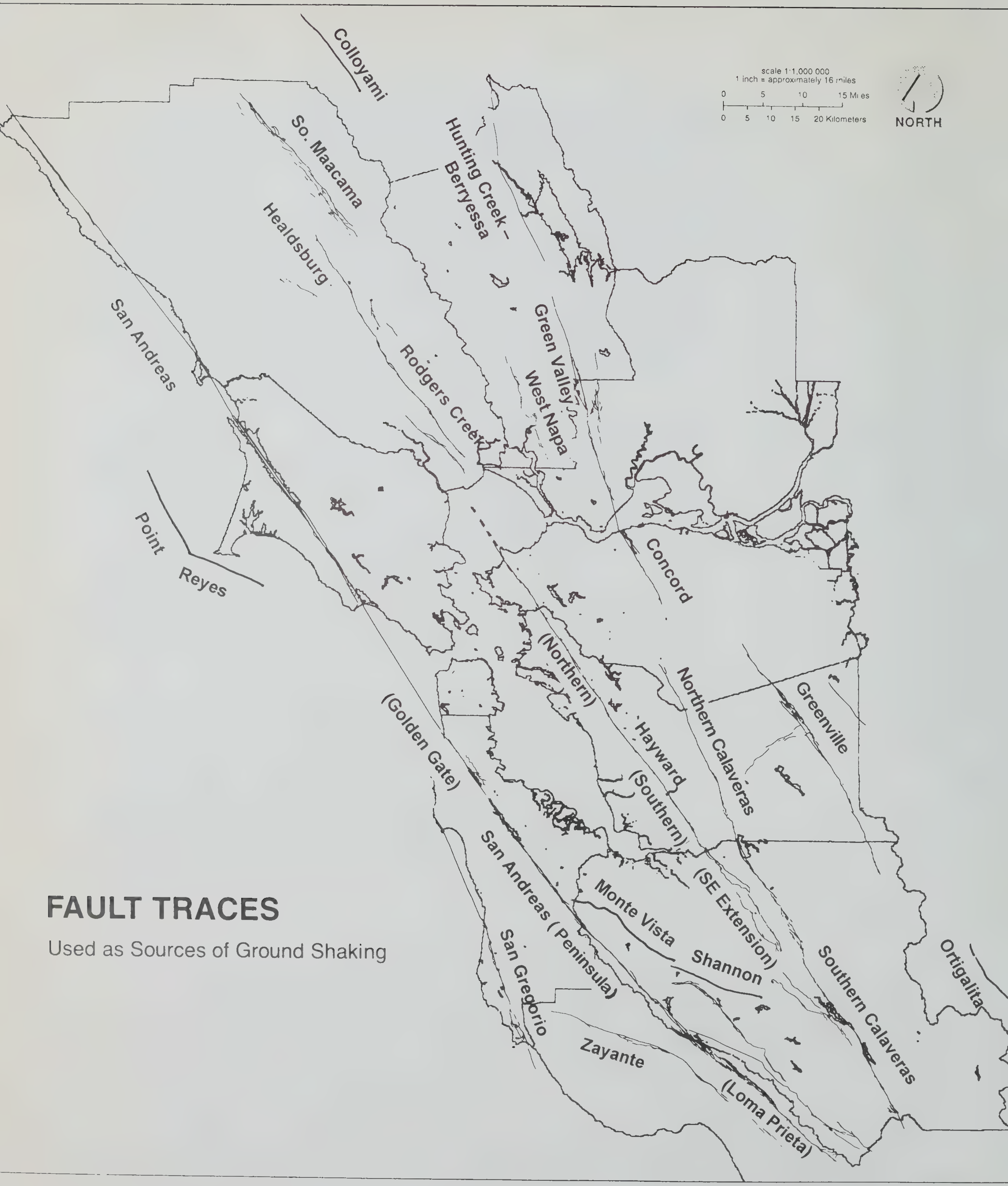
The map and table on the following pages are currently being reassessed by earthquake experts and include a great deal of uncertainty. Thus, whether you are making a decision on whether or not to purchase earthquake insurance, or whether or not to retrofit a rental property, there is no "magic answer" that either the U.S. Geological Survey or ABAG can provide to meet your needs at the present time. ABAG is postponing the release of any form of "composite map" until 1999.

Notes on the Hayward Fault –

Recently, both trenching on the northern Hayward fault and a reexamination of the historic accounts of earthquakes has moved the date of the most recent earthquake on this fault segment back to before 1776. This information will have an impact on the value in the final column on Table 8. This recent information is not incorporated into Table 8 at this time, however.

Neither Working Group report lists a separate probability for the entire Hayward fault event, even though the northern and southern Hayward fault segments may rupture together to generate this larger earthquake.

However, in the USGS/CDMG probabilistic mapping work (Ref. 13), the 167 year recurrence interval from the Working Group on California Earthquake Potential (Ref. 17) for the Hayward fault was used. They assumed that the entire fault would rupture half the time, for an average recurrence interval of 334 years, and the northern and southern segments would rupture half the time (334 years for each). These probabilities, when added together, equal the 167 year recurrence interval. These values are different than those listed in Table 8, and illustrate the uncertainty in many of the numbers provided in that table.



FAULT TRACES

Used as Sources of Ground Shaking

Source: *On Shaky Ground* – 1998

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TABLE 8: Fault Activity Information for Bay Area Faults

Fault Name	Slip Rate (mm / year)[1]	Fault Length (km)[1]	Magnitude of Characteristic Earthquake[2]	Recurrence Interval (in years)[1]	Probability of Earthquake in the Next 30 Years (Use Percentages in Right Column for Planning Purposes, When Available)	
					Based on Random Distribution of Earthquakes[1]	Based on Date of and Data from Past Earthquakes[3] [date of last known earthquake in ( )]
Entire No. Cal. San Andreas	24	470	8.2	210	14%	2% (1906)
Peninsula Segment of San Andreas (used in Ref. 17)	17	52	7.1	n/a	n/a	23 % (1838)
Peninsula-Golden Gate Seg. of San Andreas (used in Ref. 16)	17	88	7.3	400	8%	n/a (1838)
Santa Cruz Mts. (Loma Prieta) Seg. San Andreas	14	37	6.9	400	8%	~0% (1865?; 1989)
San Gregorio (incl. ocean Seg.)	5	129	7.5	400	8%	n/a
San Gregorio	5	57	7.1	n/a	n/a	n/a
Sargent	3	53	7.1	330	9%	n/a
Entire Hayward (So. +No. Seg)	9	85	7.3	n/a	n/a	n/a
Southern Hayward	9	***45***	7.0	210	14%	23% (1868)
SE Extension of Hayward	3	26	6.7	220	14%	n/a
Northern Hayward	9	***49***	7.1	210	14%	28% (pre-1776)
Healdsburg-Rodgers Creek	9	***57***	7.1	230	13%	22%
Southern Maacama	9	***32***	6.8	220	14%	n/a
Northern Calaveras (NC)	6	***37***	6.9	400	8%	n/a
NC–Amador Valley Seg.	6	15	6.5	200	15%	n/a (1864?)
NC–San Ramon Valley Seg.	6	13	6.4	200	15%	n/a (1861)
Southern Calaveras (creeping zone)	15	26 (130/~5)	6.0 (in ~5 events)	60 (for each)	50% (for each)	n/a (1984 -Morgan Hill); (1979 - Coyote Lake)
Concord-Green Valley	6	***53***	7.1	330	9%	n/a
Concord	6	23	6.7	240	12%	n/a
Green Valley	6	44	7.0	330	9%	n/a
Hunting Creek-Berryessa	6	60	7.2	170	18%	n/a
Greenville	2	***54***	7.1	550	5%	n/a (part-1980-Livermore)
Ortigalita	1	66	7.2	1100	3%	n/a
West Napa	1	***24***	6.7	700	4%	n/a
Monte Vista-Shannon -***Thrust***	0.4	41	7.0	2400	1%	n/a
Monte Vista -***Thrust***	0.4	25	6.7	n/a	n/a	n/a
Collayomi	0.6	29	6.8	1100	3%	n/a
Point Reyes - ***Thrust***	0.3	47	7.0	3500	0.9%	n/a
Zayante	0.1	56	6.8	10000	0.3%	n/a
Great Valley 03 – ***Thrust***[4]	1.5	55	7.1	620	5%	n/a
Great Valley 04 - ***Thrust***[4]	1.5	42	7.0	540	6%	n/a (1892-Winters?)
Great Valley 05 - ***Thrust***[4]	1.5	28	6.8	450	7%	n/a
Great Valley 06 - ***Thrust***[4]	1.5	45	7.0	560	5%	n/a
Great Valley 07 - ***Thrust***[4]	1.5	45	7.0	560	5%	n/a
Great Valley 08 - ***Thrust***[4]	1.5	41	7.0	540	6%	n/a
Great Valley 09 - ***Thrust***[4]	1.5	39	6.9	520	6%	n/a

Note 1. Generally based on data from Working Group on Northern California Earthquake Potential (1996) (Ref. 16). Fault lengths in ***bold italics*** have been modified based on local data. The probability values listed are additive. Thus, the probability of 1 in 400 years for an earthquake on the Peninsula-Golden Gate San Andreas segment acting independently (such as occurred in 1868) should be added to the 1 in 210 years for a repeat of the 1906 San Francisco earthquake on the entire San Andreas to obtain the ***total*** exposure for someone living next to that fault in San Mateo County (1 in 137 years).

Note 2. The formula used to estimate magnitude for strike-slip faults (from Ref. 18) is Moment Magnitude = 5.16 + [1.12 x log (surface fault length in km)]. The formula used for thrust faults (from Ref. 18) is Moment Magnitude = 5.00 + [1.22 x log (surface fault length in km)]. These magnitudes are slightly different than those in Ref. 16 because we did not incorporate fault depth, a variable with poor data.

Note 3. Based on data from Working Group on California Earthquake Probabilities (1990) (Ref. 17).

Note 4. These faults do not appear on the map due to poor information on their locations. They border the western side of the Central Valley (Ref. 16). The 1983 Coalinga earthquake (M 6.7) was on GV13. This fault segment, and others not listed, are outside the region.

Segmentation of Bay Area Faults…

The Questions

☑ **How certain are we that we are selecting the "correct" fault segments when we subdivide major Bay Area faults into these segments for use as sources of earthquakes in our models?**

☑ **Does this uncertainty effect hazard level or risk?**

Why We Want to Know

The entire length of major faults do not always rupture at one time to create a single major earthquake. Often, only a portion of a fault ruptures in an earthquake. These pieces of major faults that rupture on their own are called "***fault segments***." Geologists and paleoseismologists work to identify the likely portions of faults to rupture. These fault segments generate "***characteristic***" earthquakes which serve as the sources of earthquakes used in the ***On SHAKY Ground*** report (Ref. 1).

What We Know and Don't Know

This process of identifying fault segments is not an exact science; professional judgment is involved, in part because little evidence of past earthquake ruptures may be present. Scientists at USGS and other earthquake researchers are reexamining the segments for use in future earthquake scenarios.

For example, ABAG used the definition of the Peninsula segment of the San Andreas fault identified in the 1990 report by the Working Group on California Earthquake Probabilities (1990) (Ref. 17) in our ***On SHAKY Ground*** report (Ref. 1). The 1996 report by the Working Group on Northern California Earthquake Potential (Ref. 16) changes the definition of some fault segments, including the peninsula San Andreas, slightly. The length of this fault segment was changed from 52 to 88 km; this longer fault segment (called the Peninsula-Golden Gate San Andreas on the map which follows) extends north to outside the Golden Gate, rather than stopping on the peninsula. It is unclear which of the two versions of the San Andreas fault on the peninsula is the most likely to rupture. However, the longer fault segment will result in an earthquake which is much more serious than the shorter fault segment for both the City of San Francisco and the entire Bay Area, as shown on the following pages. ***This fault segment ranks behind the entire Hayward fault as having the potential to cause the most damage in the Bay Area.*** Unfortunately, it is impossible as this time to be completely certain which segment is "correct."

Where We're Going

The way in which faults are segmented is being rethought at the present time. We anticipate that a major change in fault segment definitions will take place by the fall of 1999 as a product of a new USGS working group.

Source: *On Shaky Ground* – 1998

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Peninsula San Andreas Earthquake Scenario

Extent

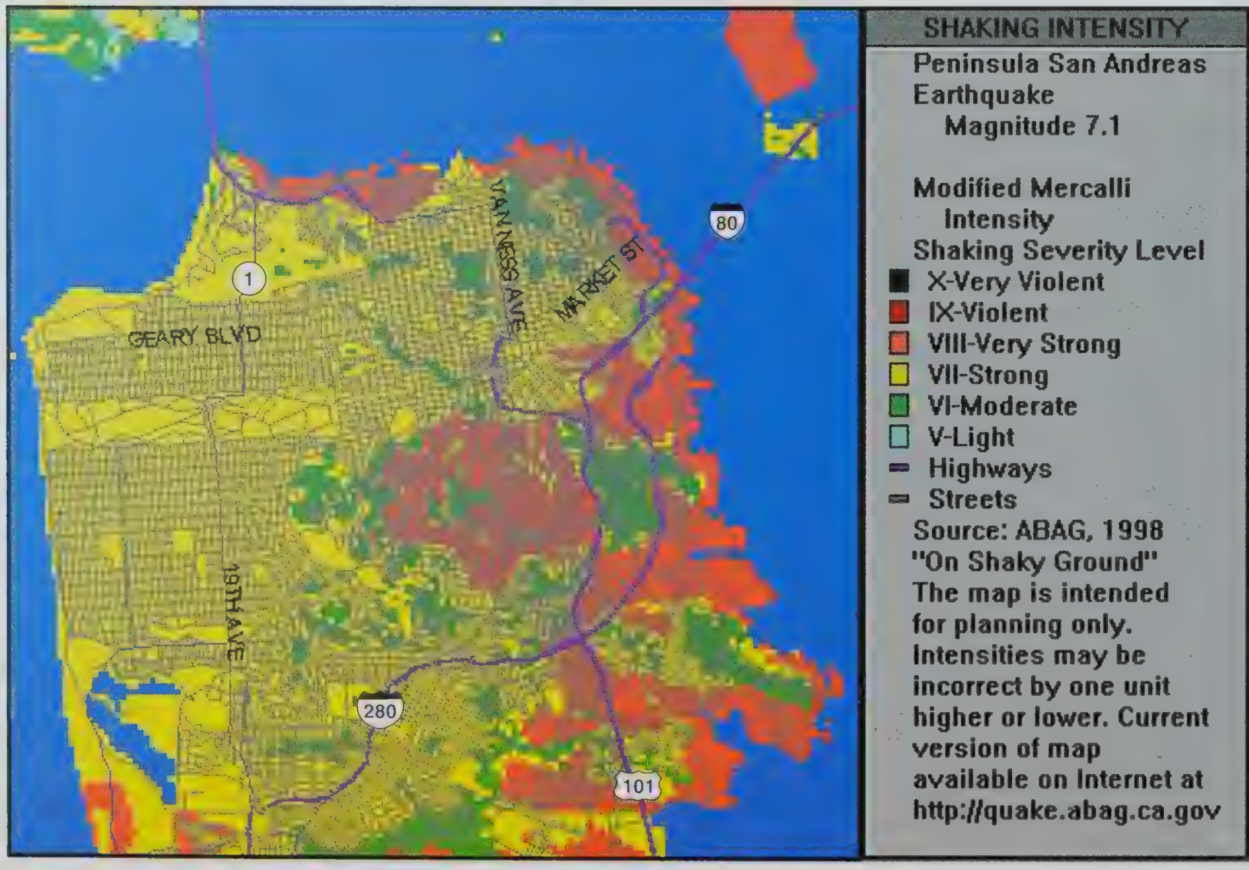
The Peninsula San Andreas fault segment was defined in the 1990 report by the Working Group on California Earthquake Probabilities (Ref. 17) as extending from the northern end of the fault source of the 1989 Loma Prieta earthquake to the northern end of Lower Crystal Springs Reservoir in San Mateo County. This fault segment is approximately 52 km long and is capable of generating a magnitude 7.1 earthquake. It is included in the 1995 ABAG report, ***On SHAKY Ground*** (Ref. 1).

Estimated Housing Impacts

Approximately 45,700 total uninhabitable housing units, including approximately 19,200 units in San Francisco. See the 1996 ABAG report, ***Shaken Awake!*** (Ref. 3).

Estimated Transportation Impacts

Approximately 428 road closures, including about 84 in San Francisco. See the 1997 ABAG report, ***Riding Out Future Quakes*** (Ref. 8).



Peninsula-Golden Gate San Andreas Earthquake Scenario

Extent

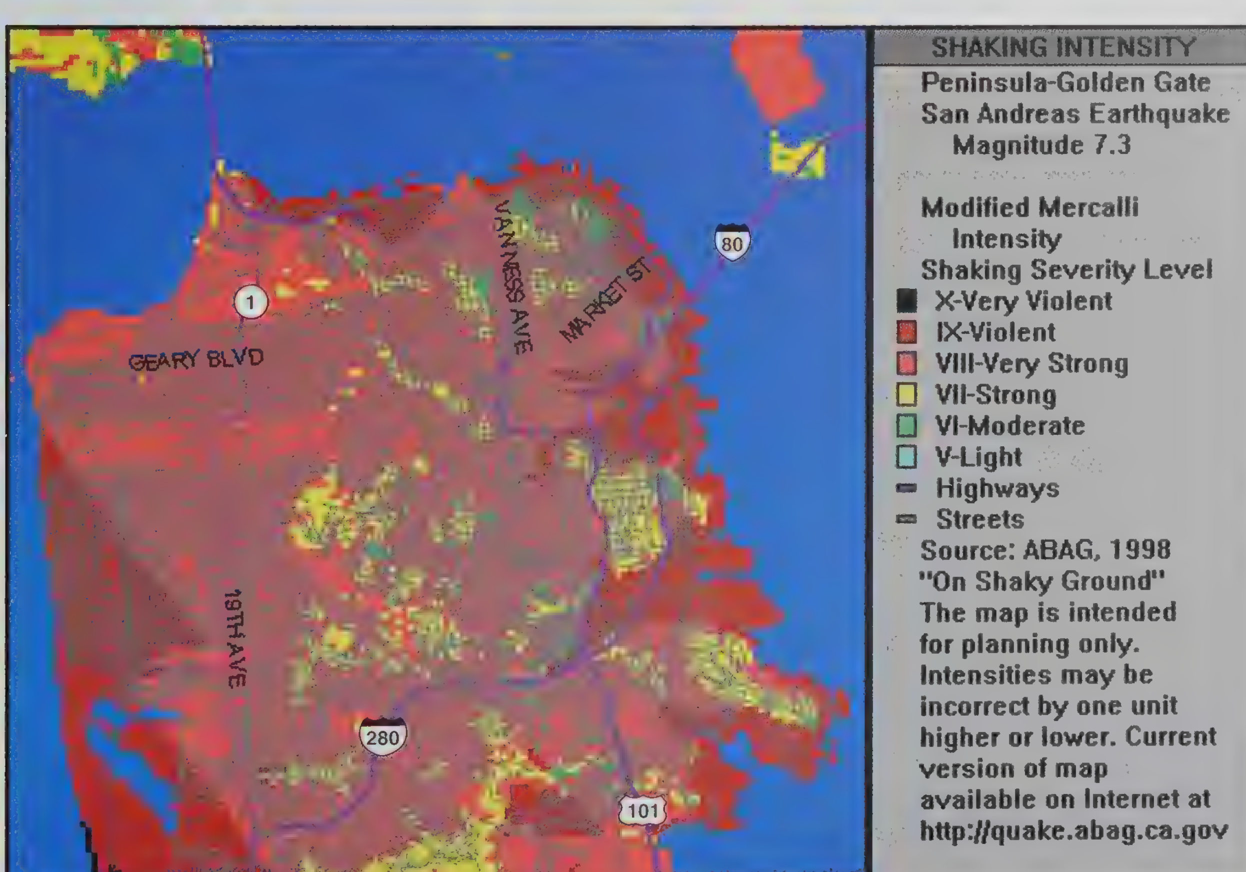
The Peninsula-Golden Gate San Andreas fault segment was used in the 1996 report by the Working Group on California Earthquake Potential (Ref. 16) as extending from the northern end of the fault source of the 1989 Loma Prieta earthquake ***beyond Lower Crystal Springs Reservoir*** to off the Golden Gate. This fault segment is approximately 88 km long and is capable of generating a magnitude 7.3 earthquake. The regional map is included in this ***On SHAKY Ground – Supplement.***

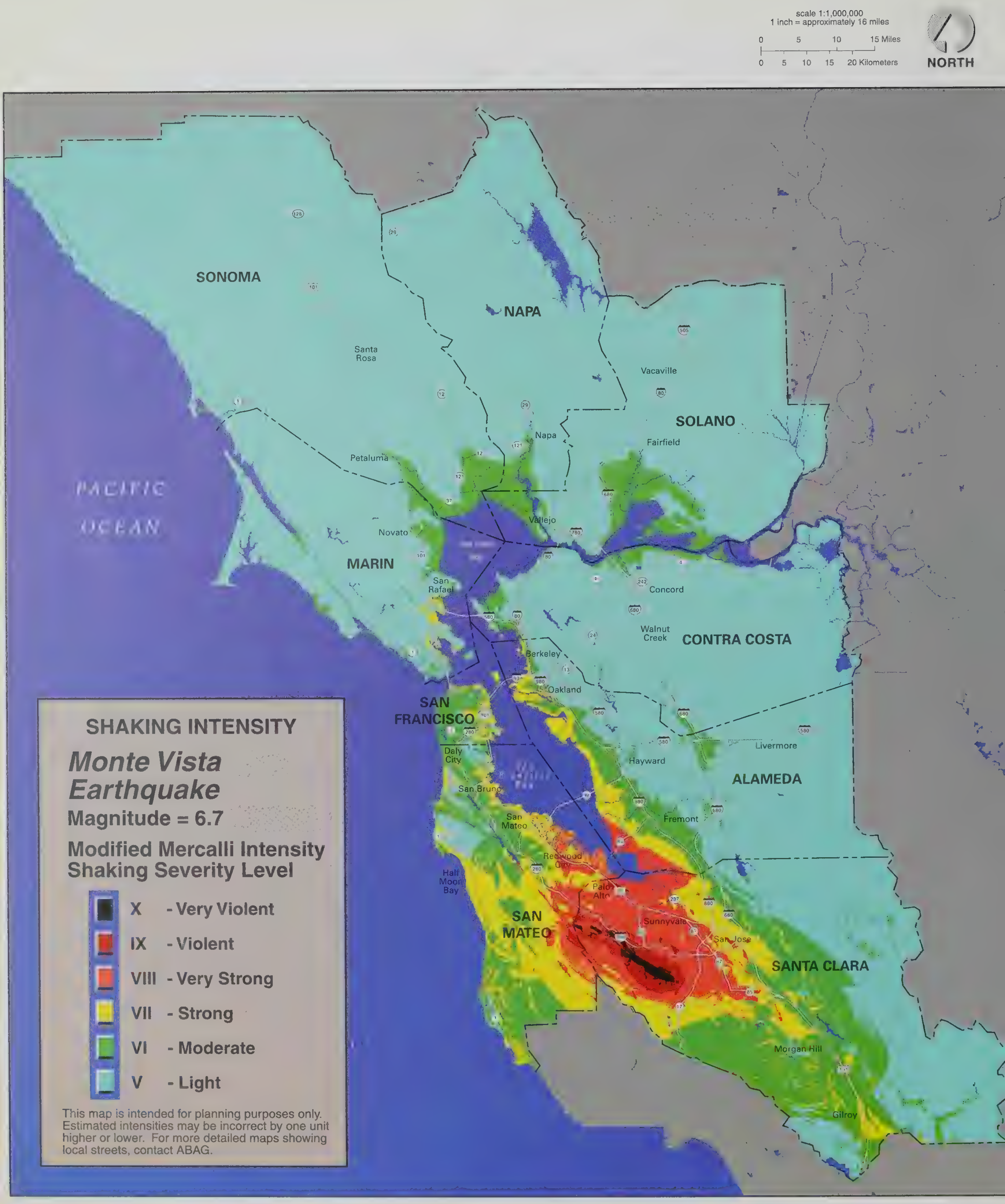
Estimated Housing Impacts

Approximately 107,200 total uninhabitable housing units, including approximately 65,100 units in San Francisco. Thus, in San Francisco alone, ABAG estimates this scenario will have over triple the impact of the smaller Peninsula-San Andreas scenario and almost double the impact of the entire Hayward scenario of approximately 38,700 uninhabitable units.

Estimated Transportation Impacts

Approximately 836 road closures, including about 356 in San Francisco. Thus, in this city, this scenario will have over four times the impact of the smaller Peninsula San Andreas scenario and more than the 228 closures from the Hayward scenario.





Source: *On Shaky Ground* – 1998
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Association of Bay Area Governments

Role of Thrust Faulting in Bay Area Earthquake Hazards…

The Questions

- ☑ **What is the role of thrust faulting in contributing to the overall earthquake risk in the Bay Area?**
- ☑ **Where are Bay Area thrust faults located?**
- ☑ **Should the shaking generated by these faults be modeled differently? If so, how?**

How Important Are Bay Area Thrust Faults?

Most of the major faults in the Bay Area are strike-slip faults, where the rupture plane extends almost vertically into the ground and the ground on one side slips horizontally past the ground on the other side of the fault. There are, however, several thrust or reverse faults in the Bay Area, where ground moves upward and over adjacent ground. (These faults are more common in southern California than the Bay Area because the San Andreas fault makes a large bend to the west there before heading northwest. Many thrust faults in southern California are caused by this bending.)

What We Do and Don't Know About Thrust Faults

In the Bay Area, thrust faults are less well understood than strike-slip faults. However, the U.S. Geological Survey is actively conducting studies of several of these faults or is funding studies by other researchers. Additional information on these faults should be available by early 1999.

We estimate that an earthquake on the Monte Vista fault might generate 15,000 uninhabitable housing units, almost as many as the Loma Prieta earthquake. Notably, 13,500 would be in Santa Clara County, making it as damaging in that county as a magnitude 7.3 earthquake on the entire Hayward fault.

One of the most dangerous Bay Area thrust faults, because of its location near an urban area, is the Monte Vista fault on the western side of the Santa Clara Valley. However, this fault has a long recurrence interval for large earthquakes – on the order of several thousand years. As with other thrust faults, we know generally where the fault is located, but it is difficult to identify the actual surface trace.

Each of the seven Great Valley faults identified in Table 8 are also thrust faults. The location and size of earthquakes generated by the Great Valley faults are less well understood than for the Monte Vista. The recurrence intervals for earthquakes on segments of this fault system are listed in Table 8 as 500-600 years, but this estimate is uncertain.

Modeling Thrust Fault Earthquakes

Because the Northridge earthquake was caused by a thrust fault and there was a small thrust component in the Loma Prieta earthquake, it is possible to test various ways to model shaking caused by movement of thrust faults. ABAG is testing such a model in cooperation with researchers at USGS. An interim map using that model is shown on the following page. Because the Monte Vista fault is not precisely located and the model is preliminary, more detailed maps are not available at this time.

PART III

How Have ABAG's Ground Shaking Intensity Maps Been Used or Not Used?

Since the latest version of ABAG's ***On SHAKY Ground*** report was released in 1995, many Bay Area local governments, utilities and businesses have used the maps for public education, in the design of hazard mitigation programs, and in the review of proposed development. The following two pages describe the uses of the maps and information by a sample local government (the City of Berkeley) and a sample utility (the East Bay Municipal Utility District – EBMUD).

Notably, at least two large real estate disclosure companies (JCP Geologists, Inc. and e-RISK) do NOT use the ***On SHAKY Ground*** maps in their routinely issued disclosure reports. The key reason for this decision is that these companies are not required to disclose the maps as part of the state-required Natural Hazard Disclosure Statement. ***Only if a city or county adopts the ABAG maps as part of their General Plan or in a local ordinance which specifically requires disclosure are companies obliged to disclose the maps.*** A description of the rationale used by JCP Geologists is included following the Berkeley and EBMUD descriptions.

LOCAL GOVERNMENT USER:	**City of Berkeley – Hazard Identification, Public Education, and Hazard Mitigation** 1995 POPULATION: 105,855 Key Contact: Arrieta Chakos City Manager's Office Phone (510) 644-6580

The City of Berkeley has used the maps from ***On SHAKY Ground*** for identifying the shaking hazard, communicating that hazard to the public and federal officials, and mitigating some of those hazards.

Elected officials, staff, and community members have referred to the maps and written materials provided in the report in a number of public forums and workshops on communicating the earthquake hazard in the City.

In recent meetings with federal officials, the maps were useful tools for showing the seismic issues Berkeley faces overlaid with the urban-wildland interface. The graphic presentation demonstrated, too, Berkeley's serious exposure to severe geologic hazards. This information coupled with building stock data made for sobering talk about pending hazard mitigation funds.

City staff have used the maps to make decisions about retrofit projects; to update municipal planning documents; and while conferring with community members about the relative risk in the regional environs. The City's general plan is currently being revised; hazard assessment information and graphics from the document will be cited in the Safety and Housing Elements.

The maps were also used in a series of community meetings detailing Berkeley's seismic risk when the voters were being asked to approve a hazard mitigation bond measure to upgrade Berkeley's main library and city hall.

On SHAKY Ground has been a popular and widely used publication in Berkeley.

Summary prepared by Arrieta Chakos, City of Berkeley.

UTILITY USER:	**East Bay Municipal Utility District – Seismic Improvement Program** 1998 WATER CUSTOMERS: 1.2 million 1998 WASTEWATER CUSTOMERS: 0.6 million Key Contact: David Lee Seismic Improvement Program (Water) Phone (510) 287-1187

The East Bay Municipal Utility District (EBMUD) has used the maps from ***On SHAKY Ground*** for verifying the shaking hazard and communicating that hazard to the public and its water supply and wastewater customers.

Geologists predict a major quake on the Hayward Fault within the next 30 years. A magnitude 7 earthquake on this fault would cause widespread damage to EBMUD's water system, possibly including:

- 5,500 pipe breaks
- major water tunnel failures cutting off sections of service area
- loss of 65 distribution reservoirs
- 87 pumping plants out of commission
- two-thirds of population without service for up to 6 months

Financial impacts in the EBMUD service area could be as much as $2-billion in repair costs and business-related losses, about ten times as much as the cost to protect the system in advance of a quake.

These impacts were identified prior to the availability of the ***On SHAKY Ground*** maps. However, after publication, these maps were then used to ensure that the conclusions of the general shaking and pipe rupture hazards were consistent with earlier predictions.

When the original EBMUD study revealed the extent of the risk, EBMUD's ***Seismic Improvement Program*** (***SIP***) staff proposed a $189-million program to strengthen the water system against major quakes on the Hayward, Calaveras and Concord faults. They asked customers if they would support and pay for the program and more than 90-percent of respondents said yes. In 1994, the Board of Directors told the ***SIP*** team to get the work done, and meet a fast-track 10-year schedule.

EBMUD's Internet Site prominently features a reference to this ***Seismic Improvement Program***. (See - http://www.ebmud.com/ebmsip/sip.html) This public information site features a link to ABAG's Internet site for ***On SHAKY Ground*** maps on the Hayward fault.

Summary prepared by Seismic Improvement Program Staff, EBMUD.

JCP Geologists, Inc.

DISCLOSURE REPORTS ISSUED SINCE: 1976
Key Contact: Nate Smith
Cupertino Office
Phone (408) 446-4426

***The Maps* -** It is important to note that the ABAG ground shaking maps are not the same as "Seismic Hazards Maps" produced under the 1990 Seismic Hazards Mapping Act. Seismic Hazards Maps are prepared by the California Division of Mines and Geology and designate areas subject to landslides, liquefaction and amplified ground shaking. Although, the ABAG maps delineate earthquake ground shaking intensity, they are not the same as those that may appear on the Seismic Hazard Maps.

The ABAG maps are just one set of many geologic maps produced by government agencies. They provide information on where ground shaking intensity would be the greatest and least from an earthquake along the major faults in the Bay Area. Ground shaking intensity is mapped using the modified Mercalli scale. This scale measures how intense an earthquake was by using the extent of damage that occurred. For example, blue areas on the ABAG maps show areas where shaking might be expressed as nothing more than small objects falling off shelves whereas areas that are colored black represent severe ground shaking areas. According to ABAG, the maps were produced by computer modeling and take into consideration earthquake size, distance to the fault, and the type of geology underlying the area (i.e. generally amplified shaking in softer soils and decreased shaking in bedrock areas).

The ABAG maps do not trigger a specific disclosure requirement like the Alquist-Priolo Fault maps or the NFIP Flood maps. The ABAG maps are not printed at a large enough scale to easily permit a site-specific determination. In addition, street names are generally not shown. The intent of these maps is to provide general public awareness of ground shaking intensity on a neighborhood by neighborhood basis and to suggest ways to mitigate the damage this hazard can cause.

***To Disclose or Not to Disclose* -** The recent legislation which introduces the Natural Hazard Disclosure Statement for use in residential transactions does not include the ABAG maps as a required disclosure. However, some local planning departments may adopt portions of the maps for use in making construction or building permit decisions. If this is the case, then local disclosure requirements may apply. The best way to be sure about this is to either call the local planning department or use a disclosure provider that includes local area disclosure items such as the Seismic Safety Element in the General Plan. Also, the general publicity that has surrounded the maps to date may have buyers and sellers asking questions about them which could make it an item to address. So, while disclosure of information based on the ABAG maps may apply to some transactions, it is not universally required. Furthermore, it is important to note that the information on the ABAG maps does not satisfy the disclosure requirements of the Natural Hazard Disclosure Statement.

Summary prepared by JCP Geologists, Inc.

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